

# VIDEO SERVER FOR VIDEO DISTRIBUTION SYSTEM

This application relates to U.S. Application Serial No.                filed on                based on Japanese Application 2000-021977, and assigned to the present assignee. The content of that application is incorporated herein by reference.

The present invention relates to a video server for transmitting a video signal in parallel to a plurality of locations using the Internet protocol, and more particularly, to a video server for a video distribution system which enables transmission of a video signal through a transmission path, which cannot use IP multicast, through protocol conversion.

15                    Simultaneous transmission of a signal such as  
a video signal to multiple locations, utilizing a  
protocol such as the Internet protocol, is referred to  
as "multicast," and a number of methods for realizing  
the multicast have already been proposed, with some of  
20 such methods already brought into practical use. A  
representative one of these methods is the Internet  
multicast technology which has been published as a  
standard designated "RFC1112" of Internet Engineering

A critical component of the multicast technology is a host group model. Multicast information is transmitted to a host group indicated by some multicast address, such that each of terminals attempting to share the multicast information receives the information addressed to the host group. In a network based on the Internet protocol, multicast information is accompanied by a "multicast address," used as a destination address, which indicates that the information is multicast.

However, the effectiveness of the multicast-based transmission is limited only to those paths which support the multicast from an origination to all

5 freely passing therethrough.

15 ently by different organizations.

25 mission cost.

intended for file transfer, so that although they can

5 transmission of video and audio contents. Therefore, a mechanism for matching the transmission rate between reception and transmission of video and audio contents is required for protocols which pass the information through firewalls.

## 10 SUMMARY OF THE INVENTION

It is an object of the present invention to provide a video server for a video distribution system which is capable of solving the above-mentioned problems, and transmitting the same video from a video server to a plurality of terminals utilizing the multi-  
15 cast to reduce the transmission cost even when fire-walls are interposed between the video server and the terminals.

It is another object of the present invention  
20 to provide a mechanism for matching the transmission  
rate between reception and transmission in an  
asynchronous transmission network.

To achieve the above object, the present invention provides a video server for distributing a digitized video content, which includes a unit for determining whether or not a video content requested from a terminal is stored in the video server, a unit

for transmitting a transmission request to another video server for transmitting the video content thereto in accordance with the HTTP (Hyper-Text Transfer Protocol) protocol when the video content requested by the terminal is not stored in the video server, and a unit for receiving the video content transmitted from the other video server in accordance with the HTTP protocol and transmitting the video content to the terminal in accordance with the IP multicast or the HTTP protocol.

The transmission unit further includes a plurality of buffers, a buffer selector, and a reference time generator. The transmission unit detects a random access point in image information, and stores the image information up to the next random access point in one of the plurality of buffers. The buffer selector selects, from among the plurality of buffers, image information which has not been transmitted and has a time stamp equal to or smaller than a reference time generated by the reference time generator, and indicates the selected image information to the transmission unit.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating an example of a video distribution system in which two video servers according to the present invention are connected through a transmission path which does not

allow IP multicast to pass therethrough;

Fig. 2 is a flow diagram for explaining the operational flow of the video distribution system utilizing the video servers described in Fig. 1;

5 Fig. 3 is a flow chart for explaining the operation of the video server system illustrated in Fig. 2;

Fig. 4 is a diagram illustrating an example of management information stored in video management  
10 tables 204, 214;

Fig. 5 is a block diagram illustrating an exemplary configuration of a video delivery unit;

Fig. 6 is a diagram illustrating an exemplary format for image information;

15 Fig. 7 is a diagram for explaining an example of extended functions for the video delivery unit; and

Fig. 8 is a diagram for explaining an exemplary video transmission method according to the HTTP protocol.

## 20 DESCRIPTION OF THE EMBODIMENTS

### (1) System Configuration

Fig. 1 illustrates an example of a video distribution system in which two video servers according to the present invention are connected through a  
25 transmission path which does not allow IP multicast to pass therethrough.

A video content stored in a video storage

102A of a video server 101A can be transmitted simultaneously to client terminals 103A through an IP network 12A using an IP multicast transmission scheme.

However, as to client terminals 103B  
5 connected to an IP network 12B, IP multicast based  
transmission cannot be realized from the video server  
101A to the client terminal 103B, though connected to  
the network 12B, because a network connecting the IP  
network 12A and the IP network 12B has a firewall 104  
10 interposed therebetween and serves as a network  
dedicated to HTTP.

To eliminate this inconvenience, the present invention transmits image information using the HTTP protocol only when the image information is passed through an HTTP network. For example, when a client terminal 103B requests to view a video content stored in the video storage 102A and multicast to the client terminals 103A, the video server 101A transmits image information to the client terminals 103A using the IP multicast, and simultaneously transmits the image information to the video server 101B through the HTTP network 11 using the HTTP protocol.

The video server 101B receives the image information transmitted from the video server 101A, and multicasts the image information to the client terminals 103B using the IP multicast.

A logical transmission path in accordance with the HTTP protocol between the video servers 101A

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tional flow of the video distribution system utilizing the video servers described in connection with Fig. 1.

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The video servers 101A, 101B comprise



## (2) Distribution of Video

In the following, the operational flow in the video distribution system illustrated in Fig. 2 will be explained along the flow chart of Fig. 3.

On the other hand, when the requested video content is not stored in the video storage 206 (step



operational flow, the video delivery unit 215, upon receipt of the transmission command 27, uses the HTTP protocol to retrieve image information of interest from the video storage 216 and transmit the retrieved image information to the video delivery unit 205 in the video server 101B in accordance with the transmission command 27 (step S7). Upon receipt of the reception parameters 26, the video management unit 203 sends the transmission command 23 adapted for the parameters 26 to the video delivery unit 205, and transmits to the client terminal 103B reception parameters 22 which are attribute information of the video content required to receive the video content (step S8).

The video delivery unit 205 receives a HTTP-based video content 28 from the video delivery unit 215 in the video server 101A in accordance with the received transmission command 23, and again transmits the video content 28 to the client terminal 103B as image information 24. In this event, the image information received by the video delivery unit 205 is also stored in the video storage 206 for registering its title and so on in the video management table 204 as a cache which is temporary information (step S9).

Subsequently, when an audience request for the same video content is again transmitted from an client terminal, the video management unit 203, at this time, can find the requested video storage registered in the video management table 204 as a cache, sends a

5 event, since the image information need not be  
retrieved and transmitted from the video storage 216 in  
the video server 101A, a large reduction in the trans-  
mission cost can be accomplished.

In Fig. 4, assume that a server 1 is a video server which holds the video management table, and servers 2, 3, ... are other video servers. The video management table describes perfect information on video contents stored in the server 1. For video contents stored in the other servers 2, 3, ..., information on video contents once transmitted in the past is described in a cache directory. An audience request for a video content which is not described in the cache directory is queried sequentially to the other servers as mentioned above. Each video content is managed by a video title (for example, "movie 1"), attribute information thereof (the type of the video content, initialization parameters for decoding the video content, dimensions of the vertical side 720 and the horizontal side 480, and so on), the location of the file (for example, a file name such as "video A.movie"), and so

The example of Fig. 4 shows that video contents 3, 4 are recorded in a directory 1 of the server 1; video contents 5, 6 in a directory 2; a directory 4 and a video content 7 in a directory 3; video contents 8, 9, 10 in the directory 4; and video contents 1, 2 directly in the server 1. Also, Fig. 4 shows in the cache directory that video contents 11, 12, 13, 14 have been once transmitted from the servers 2, 3, 4, respectively, and stored in the server 1 as caches.

Since image information is often compression encoded using differential information, it is not always the case that a video content can be restored whichever location the information is decoded from. More frequently, the reproduction of a video content can be started only from a particular point. As an example, Fig. 6 illustrates image information which is compressed using MPEG (Moving Picture Experts Group). A video content can be regarded as a sequence of a plurality of still images.

A plurality of information pieces for still  
25 images forming part of a video content are designated  
501A, 502A, 502B, 502C, 501B. When the video content  
is encoded, differential information between one image  
and the following image is used for encoding a majority

of still images 502A, 502B, 502C within this sequence of still images, so that it is difficult to retrieve and decode only such still images. These still images are referred to as "P frames."

5           On the other hand, some of the still images  
such as 501A, 501B are encoded independently of  
previous and following still images such that the video  
content can be started from these images. These still  
images are referred to as "I frames." If the video  
10 content is decoded from the beginning of a header added  
to the beginning of codes in an I frame, the video  
content can be correctly decoded. For this reason,  
this point is referred to as a "random access point."

The video content is further divided into smaller fragments (packets) 503A, 503B, 503C, 503D, 503E, ..., 503F, 503G, 503H when it is transmitted. Within these packets, the head packet 503A (503G as well) of the packets comprising an I frame image stores a time stamp 505 which describes a relative time at which the information is reproduced in a packet header 504. Packets included between the head packets of two consecutive I frames, for example, packets 503A - 503F in Fig. 6 define a minimum unit for reproducing the video content. When packets are stored in a buffer or the like, they are stored in minimum units N (N is a natural number and variable).

(3) Transmission of Video Content from Video Server to Terminal

Fig. 5 is a block diagram illustrating an exemplary configuration of the video delivery unit.

The video delivery unit illustrated in Fig. 5 corresponds to the video delivery unit 205 in the video server 101B previously described with reference to Fig. 2, and shows a specific configuration for delivering HTTP-based image information transmitted from the other video server 101A to the client terminal 103B.

As illustrated, the video delivery unit comprises an HTTP reception buffer 401; an HTTP receiver 402; a file writer 403; a video storage 404; a file reader 405; speed adjusting buffers 406A - 406C; a buffer controller 407; a transmission controller 408; and a transmission reference time generator 409 for generating a reference time for transmission.

In this configuration, image information 28 incoming from another video server (corresponding to the video server 101A in Fig. 2) is temporarily stored in the HTTP reception buffer 401. The HTTP receiver 402 sequentially reads the image information 28 from the HTTP reception buffer 401, examines a packet header to detect a random access point, and stores the image information 28 in the aforementioned minimum units, which allow correct decoding of the video contents, in the speed adjusting buffers 406A, 406B, 406C. While the video delivery unit of this example is provided with three speed adjusting buffers, the same operation principles can be applied if two or more buffers are

provided.

It is the buffer controller 407 that manages which image information from the HTTP reception buffer 401 should be stored in which speed adjusting buffer.

5 The buffer controller 407 instructs the HTTP receiver 402 to select the buffer which is not currently used for transmission and into which the preceding image information was written least recently, and to perform a write into the selected buffer. In other words, the  
10 three speed adjusting buffers are equally used in order except for that actually in use for transmission.

The transmission controller 408 reads a video content from one of the speed adjusting buffers 406A, 406B, 406C and transmits it to the client terminal as  
15 image information 24. In this event, it is again the buffer controller 407 that determines from which speed adjusting buffer the image information is read. The buffer controller 407 selects in order such buffers that are not currently being written and from which the  
20 contents have not been read.

The transmission controller 408 reads a time stamp of the image information read from the selected speed adjusting buffer, and compares the time stamp with the reference time 42 received from the trans-  
25 mission reference time generator 409. When the time stamp value is equal to or smaller than the reference time 42, the image information 24 is sent to the terminal through the IP multicast. Once the trans-



mission is completed, the transmission controller 408 dequeues the image information in the buffer. On the other hand, when the time stamp value is larger than the reference time, the transmission controller 408  
5 discards the image information rather than transmitting it to the terminal, and also dequeues the image information from the buffer. In other words, the video controller 408 discards image information exceeding the transmission capability in order to prevent a delay  
10 from occurring in course of transmission/reception.

The image information received by the HTTP receiver 402 is sent not only to the speed adjusting buffers but also to the file writer 403 for storage in the video storage 206. Also, when an audience request  
15 is sent for image information which has been stored in the video storage 206, the file reader 405, instead of the HTTP receiver 402, reads the requested image information from the video storage 206 and stores it in the speed adjusting buffers 405A, 406B, 406C.

20 Fig. 7 is a diagram for explaining an example of extended functions for the video delivery unit of the present invention.

In Fig. 7, an HTTP reception buffer 401, an HTTP receiver 402, a file writer 403, a video storage  
25 206, a file reader 405, speed adjusting buffers 406A, 406B, 406C, a buffer controller 407 operate in the same manner as their respective counterparts in Fig. 5. A multicast transmitter 408 operates in the same manner

as the transmission controller 408 in Fig. 5.

The embodiment of Fig. 7 includes a transmission function, added to the embodiment of Fig. 5, for transmitting image information to a plurality of client terminals in accordance with the HTTP protocol. Since the HTTP protocol is essentially intended for point-to-point communications, it is not suitable for transmitting the same information simultaneously to a plurality of terminals.

Therefore, this embodiment separately provides HTTP transmission controllers corresponding to a terminal A 603A and a terminal B 603B, respectively. An HTTP transmission controller 601A is responsible for transmission to the terminal A 603A, and has a buffer 602A for temporarily storing information to be transmitted. Similarly, an HTTP transmission controller 601B is responsible for transmission to the terminal B 603B, and has a buffer 602B for temporarily storing information to be transmitted. A similar configuration may be applied for transmitting image information to three or more terminals.

In Fig. 7, the terminal A 603A first transmits a video transmission request 64A in sequence to the HTTP transmission controller 601A. The HTTP transmission controller 601A, upon receipt of the video transmission request 64A, reads information from the buffer 602A for transmission to the terminal A 603A as image information 63A. As the buffer 602A has a free

space, the HTTP transmission controller 601A reads image information to be next transmitted from one of the speed adjusting buffers 406A, 406B, 406C, and stores the read image information in the buffer 602A.

5 In this event, it is the buffer controller 407 that determines from which speed adjusting buffer image information is read, as is the case of Fig. 5.

The buffer controller 407 selects a speed adjusting buffer which stores the most recent image  
10 information that has not been transmitted to the terminal A 603A, and into which image information is not being written. The buffer controller 407 selects a like speed adjusting buffer for the terminal B 603B. Subsequently, at the time the multicast transmission  
15 controller 408 has read and transmitted the contents (image information) of the buffer, the contents of the buffer are deleted.

The HTTP transmission controllers 601A, 601B have the same transmission reference time generator as  
20 that designated by 409 in Fig. 5, and transmits image information in the buffers 602A, 602B to a terminal such that no delay occurs.

Fig. 8 is a diagram for explaining an exemplary video transmission method between a video  
25 server and a terminal according to the HTTP protocol.

In this example, one or more HTTP communications are simultaneously performed for improving the utilization efficiency of transmission paths.

Specifically,  $N$  ( $N \geq 2$ ) logical transmission paths are established between a video server and a terminal for use in sending a video content.

Generally, the HTTP protocol involves a  
5 procedure in which the transmission side responds to a transmission request from the reception side, so that a transmission path is left unused until a response is returned from the transmission side after the transmission request has been sent from the reception side,  
10 thereby causing a lower efficiency. To solve this problem, this embodiment enables a plurality of transmission requests to be issued to a server even for a period from the time the first request has been issued to the time a response is returned.

15 A video content from a image information source 701 is stored in the speed adjusting buffers 702A, 702B, 702C, in a manner similar to the embodiment of Fig. 5. The video content stored in the speed adjusting buffers 702A, 702B, 702C is overwritten or  
20 erased from the oldest one irrespective of whether it has been transmitted or not. A selector 703 selects, in response to a request from a transmitter associated with each terminal, selects a speed adjusting buffer which stores the most recent video content and into  
25 which a write is not being executed, from among the speed adjusting buffers 702A, 702B, 702C, and sends the contents of the selected speed adjusting buffer to the transmitter.

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A transmitter is provided in correspondence to each reception side for responding to requests from a plurality of transmission sides. For example, a transmitter 704A is provided for a receiver 708A of a terminal A, and a transmitter 704B is provided for a receiver 708B of a terminal B. The transmitter 704A for the terminal A and the receiver 708A of the terminal A are connected over a transmission path 707 through a plurality of independent logical transmission paths in accordance with the HTTP protocol. In this example, three HTTP protocol connections are used. The transmitter 704B for the terminal B and the receiver 708B of the terminal B are also connected in a similar manner.

15           An HTTP reception controller 709A provided in the receiver 708A of the terminal A transmits a transmission request 71 to the transmitter 705A for the terminal A. As a response to the request, a video content 72 is transmitted from the HTTP transmitter 705A to the HTTP reception controller 709A. Similarly, an HTTP reception controller 709B receives a video content from an HTTP transmission controller 705B, and an HTTP reception controller 709C receives a video content from the HTTP transmission controller 705C.

25           Each of the HTTP reception controllers 709A, 709B, 709C in the terminal A transmits the next transmission request 71 to the HTTP transmission controller 705A, 705B, 705C associated therewith



5 HTTP reception controllers 709A, 709B, 709C does not  
always reach in order. Further, the HTTP reception  
controllers 709A, 709B, 709C may fail to receive image  
information due to communication failures or the like.

10 information received at the HTTP reception controllers  
709A, 709B, 709C must be sent to a decoder 712A after  
it is rearranged in correct order. A selector 711  
compares a time stamp stored in a decoded time stamp  
memory 710 with time stamps of the image information  
15 which has reached the HTTP reception controllers 709A,  
709B, 709C to select the HTTP reception controller  
which stores the least recent image information except  
for already decoded image information, and sends the  
image information stored therein to the decoder 712A.

20           After the image information is sent to the  
decoder 712A, the associated HTTP reception controller  
again sends a transmission request 71 to the HTTP  
transmission controller. A time stamp of the image  
information sent to the decoder 712A is stored in the  
25 decoded time stamp memory 710. If image information  
previous to the decoded time stamp reaches any of the  
HTTP reception controllers 709A, 709B, 709C, the HTTP  
reception controller stops receiving the image informa-

tion at that time, discards the image information which has been received, and immediately sends the next transmission request 71.

The operations in the transmitter 704B for  
5 the terminal B, the receiver 708B for the terminal B,  
and a decoder 712B are similar to the foregoing.

As described above, the HTTP protocol based video transmission method using a plurality of logical transmission paths can be applied to video transmission/reception between video servers.